Mestrado Integrado em Eng. Electrotécnica e Computadores

RADIOPROPAGAÇÃO

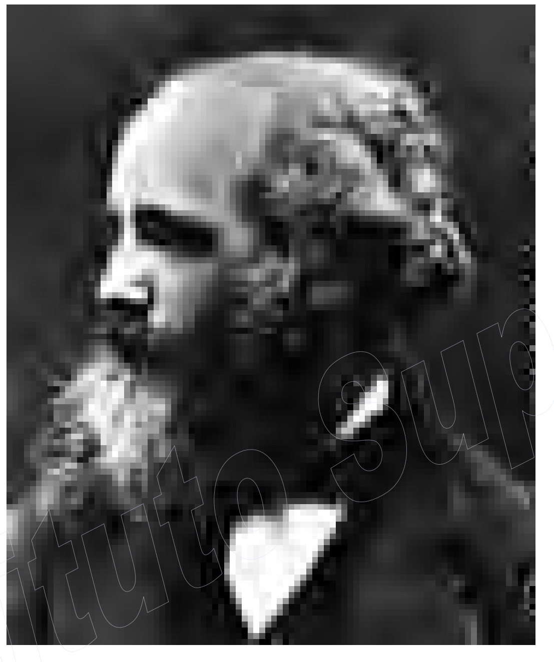
Radio Wave Propagation

Introduction

Carlos A. Fernandes

1. Just go wireless !

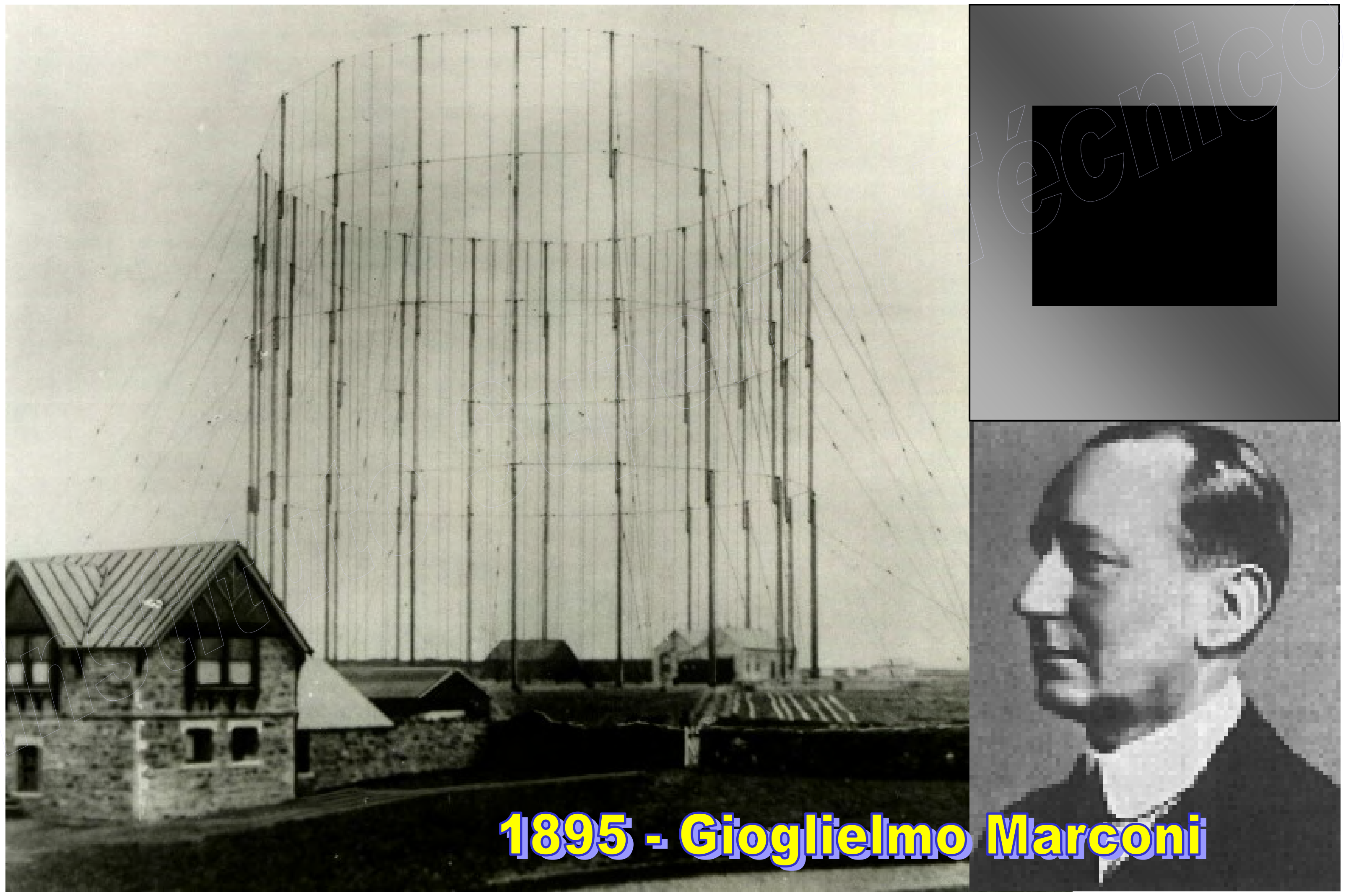
2. Who started it ?



Maxwell
(1831-1879)

Hertz
(1857-1894)

2. Who started it ?



1895 - Gioglielmo Marconi

3. Historical perspective

Key marks

1873 - James Maxwell

1887 - Heinrich Herz (experimental verification of Maxwelleqs.)
1895 - Marconi, Popov (developed communication applications)

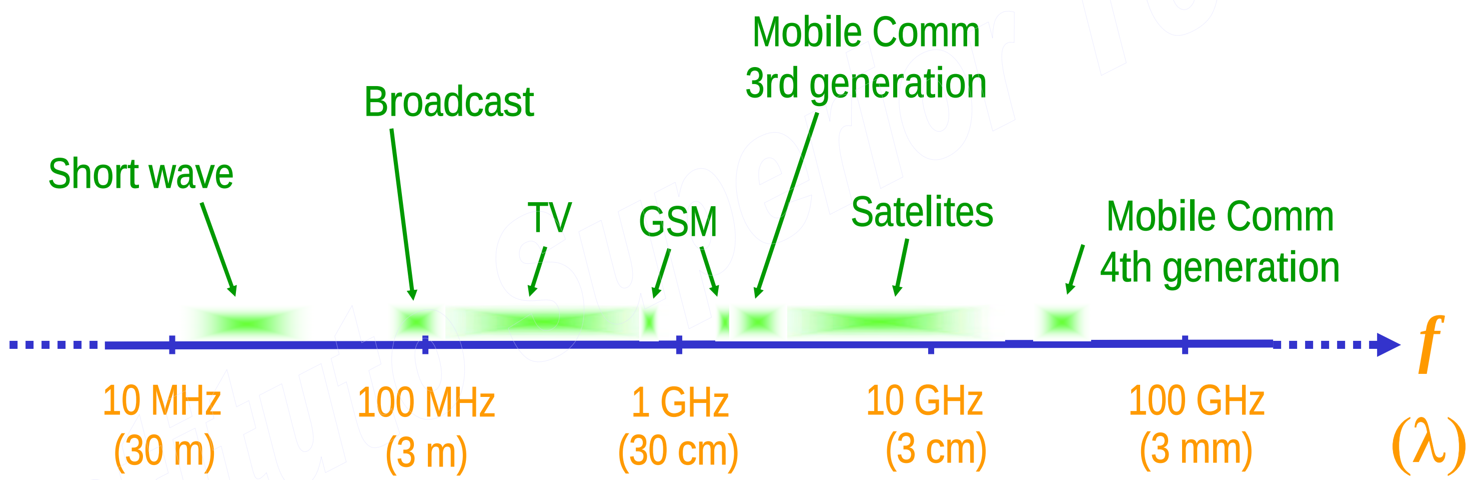
1901 – First transatlantic radio transmission;
1903 – Start of commercial radio-telegraphy;
1913 – Invention of the triode;
1923 – First radio broadcast of audio signals;
1930 – Discovery of cosmic radiation;
1945 - Arthur C. Clark proposes the use of satellites for comm
1945 – Invention of the transistor

4. Radio propagation scenarios

Radio wave propagation mechanism is influenced by scenario characteristics

5. Services

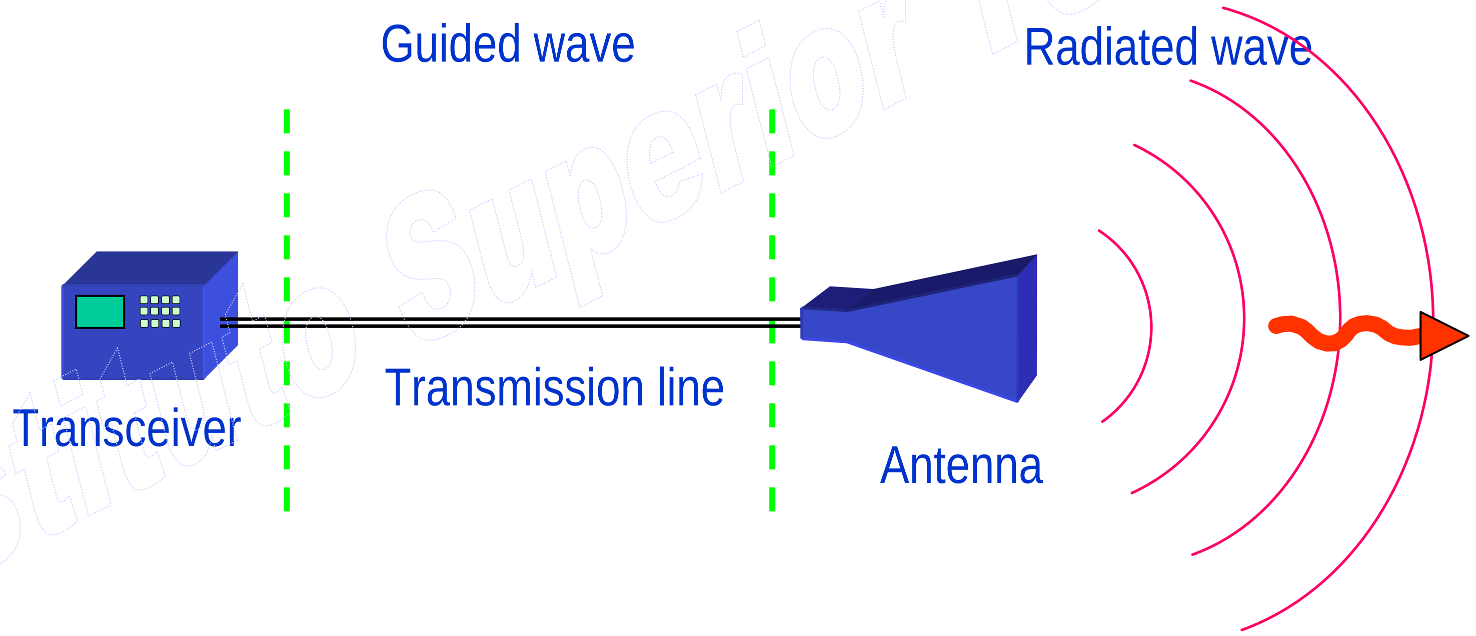
Radio communications spectrum



Tendency to shift to higher frequencies:

- Antenna dimension must be at least of the order of $\lambda/2$ to be efficient;
- Congestion of the low frequency part of the spectrum

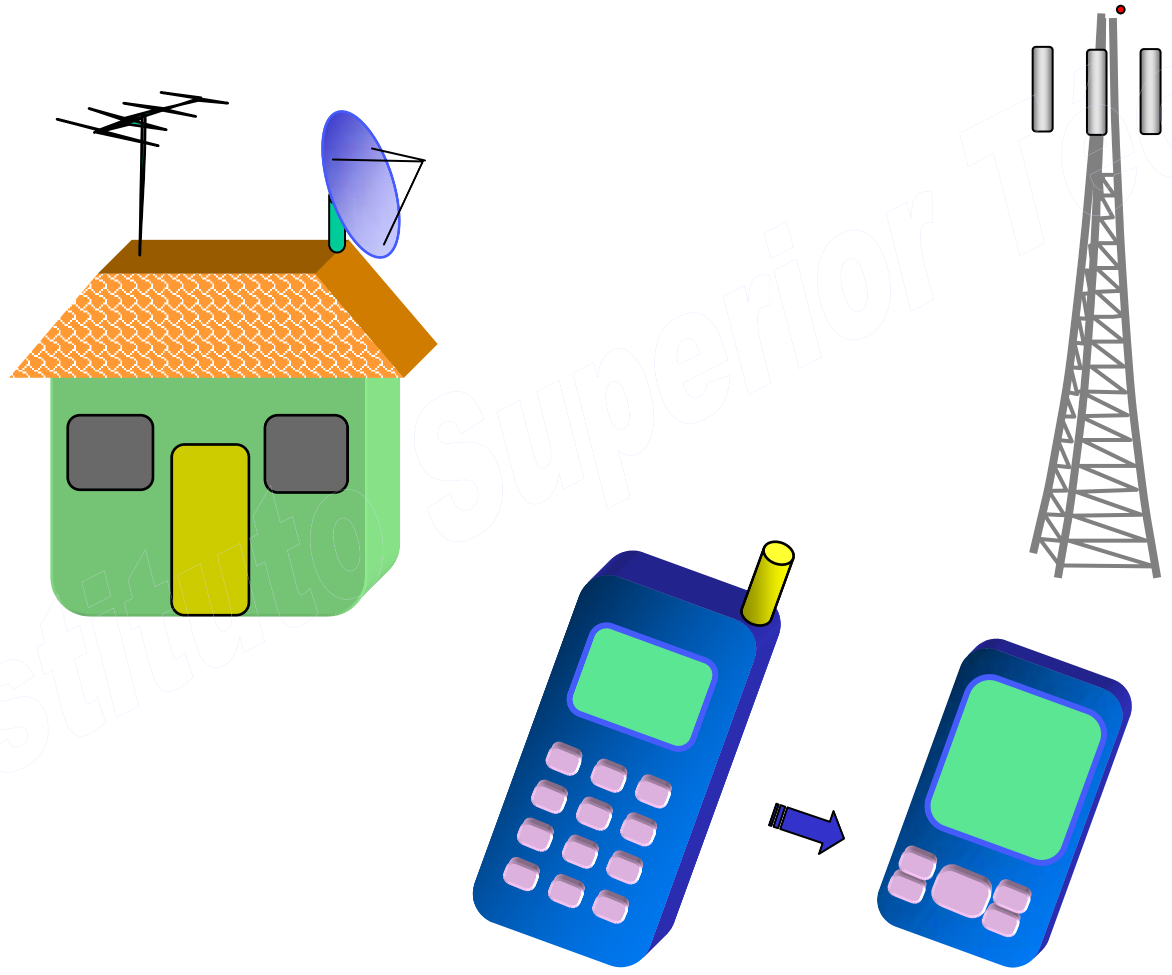
6. Transmission and reception systems



- Antennas are transducers between guided and radiated waves
- Provide directivity (which may increase with antenna size)
- Antennas are efficient only if its dimensions are comparable or > $\lambda/2$ (implies the use of high frequency)

7. Antennas

7.1 Most common antennas



7. Antenas

7.2 Exotic antennas

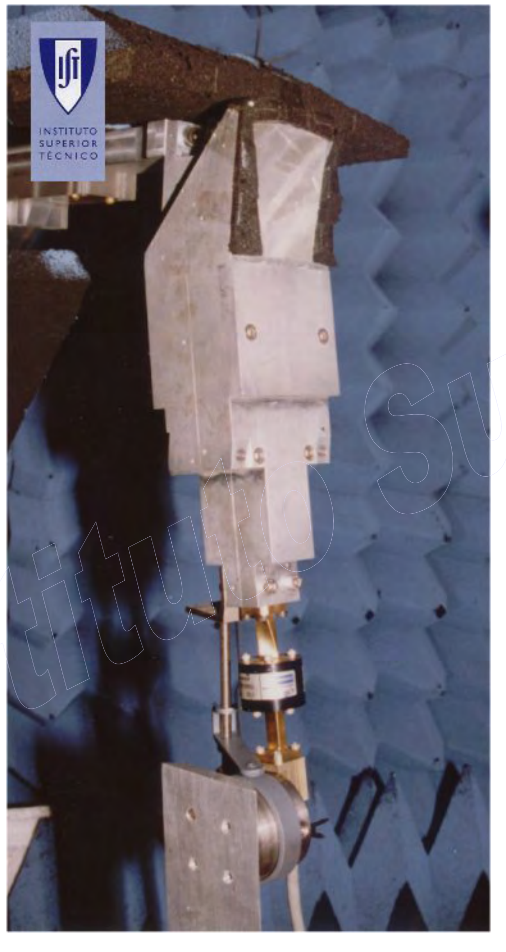
MBS

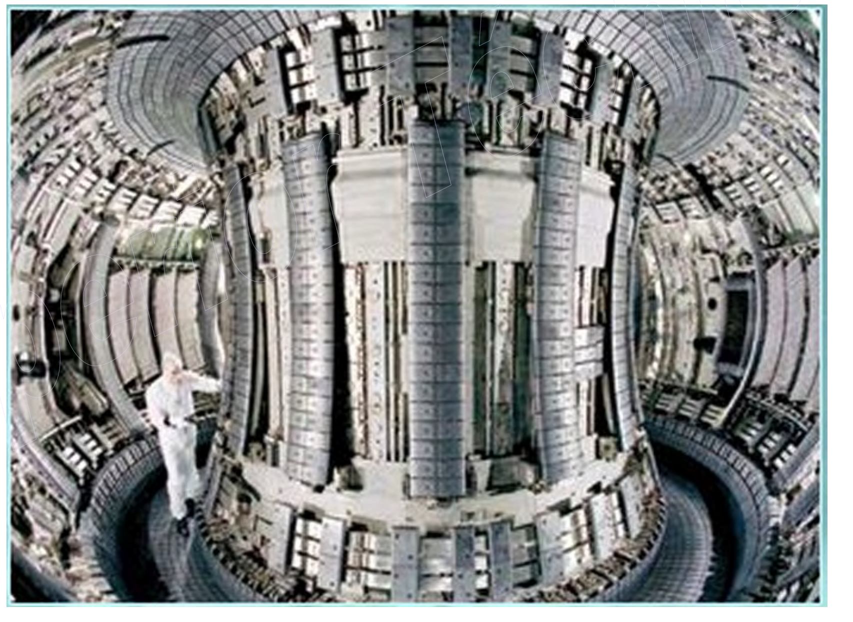
SETI

Po-SAT

7. Antenas

7.2 Exotic antennas





Hog-horn antenna for plasma fusion

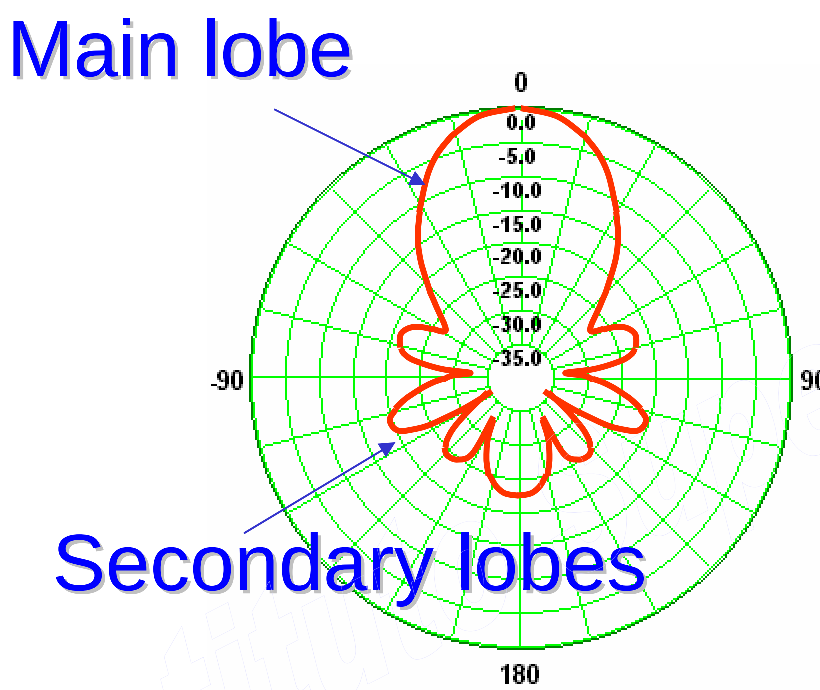
7. Antennas

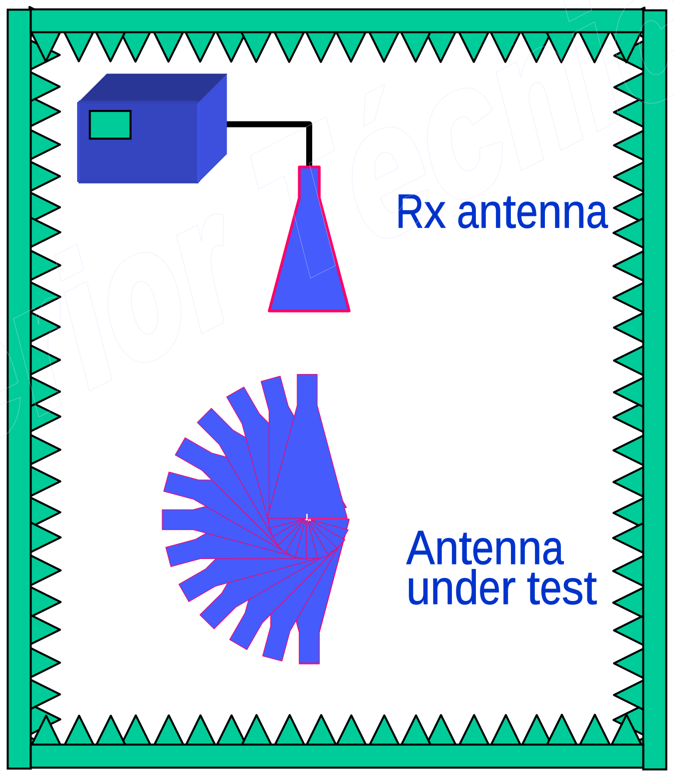
7.2 Exotic antennas

Lens antennas for space applications

ESA/ESTEC ILASH Project
Instituto de Telecomunicações

7. Antennas

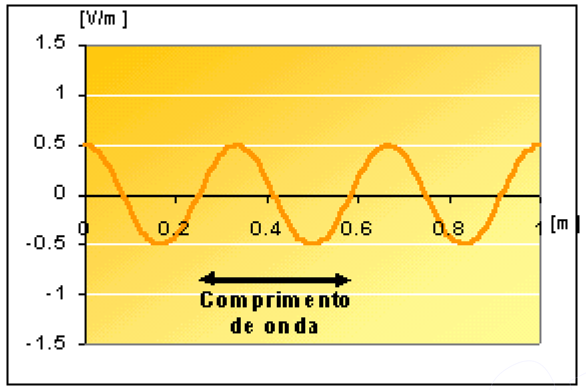


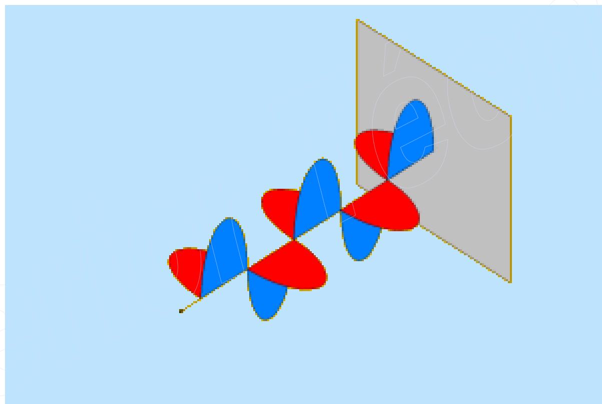


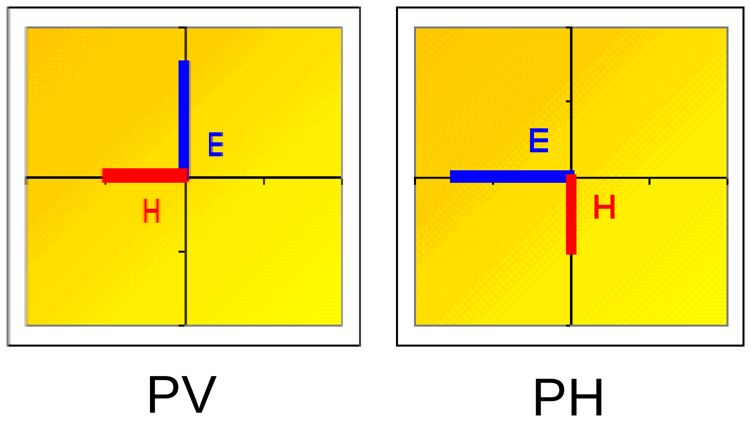
Radiation pattern: graphical representation spatial power density distribution

7. Antennas

7.3 Polarization

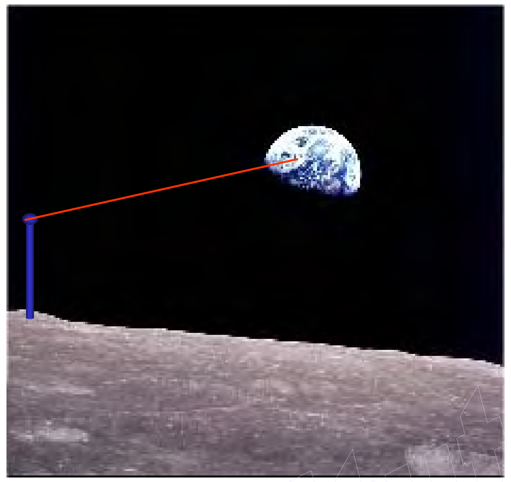






8. Free-space propagation

8.1 Link between two antennas



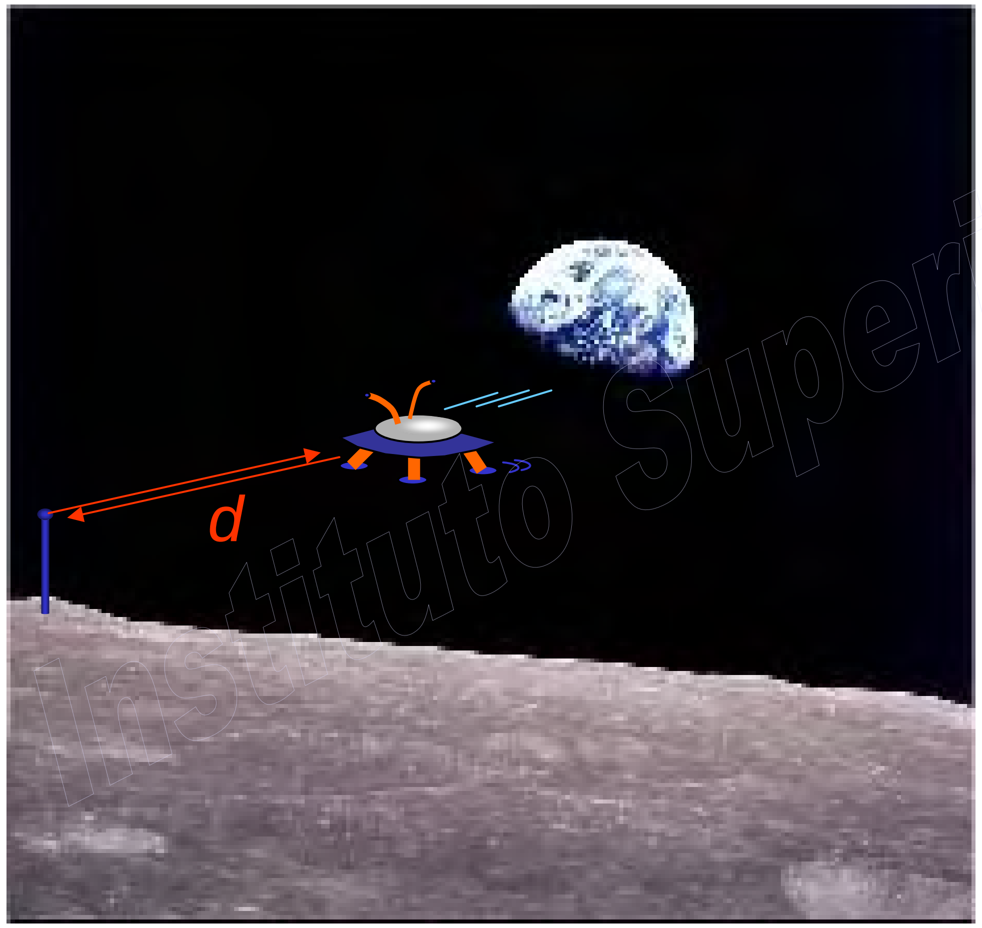
$$E = \frac{\sqrt{60\, P_e\, G_e}}{d} \qquad H = \frac{1}{d}\sqrt{\frac{P_e\, G_e}{240\,\pi^2}}$$

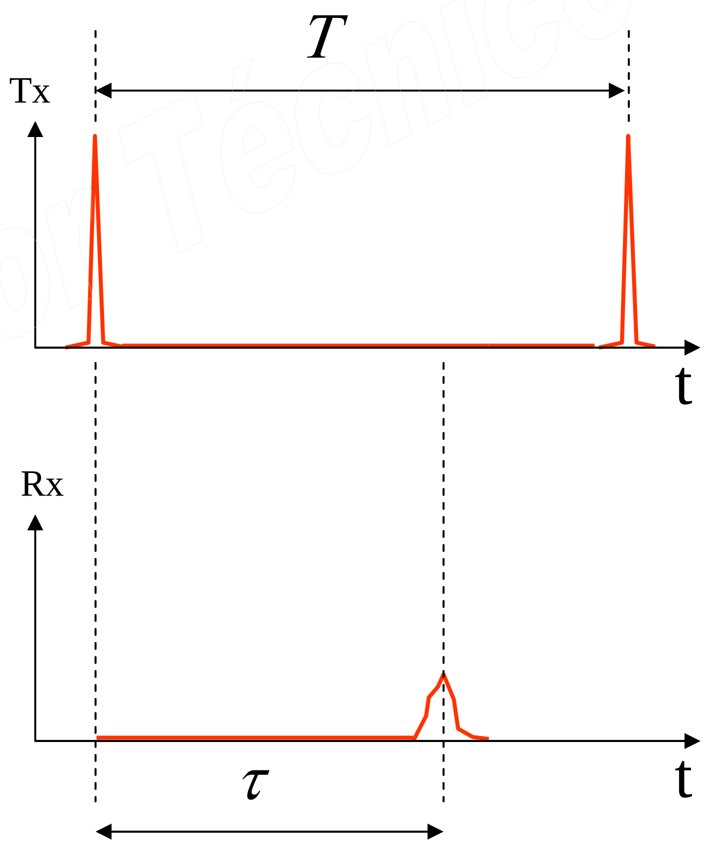
$$P_r = P_e\; G_e(e)\; G_r(r)\; \frac{1}{(4\pi)^2}\left(\frac{\lambda}{d}\right)^2$$

$$\left(\frac{P_r}{P_e}\right)_{dB} = (G_e)_{dB} + (G_r)_{dB} - 21.984 + 20\log\left(\frac{\lambda}{d}\right) + (\,L\,)_{dB}$$

8. Free-space propagation

8.2 Radar



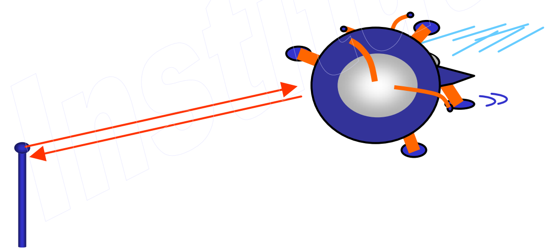


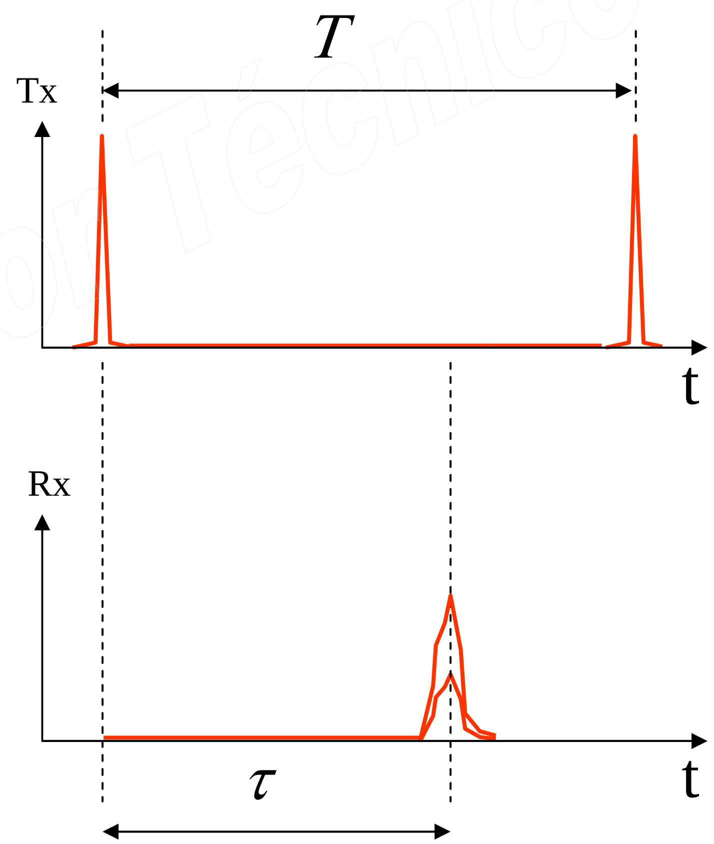
$$d = c\ \tau/2$$

8. Free-space propagation

8.2 Radar cross-section

$$P_r(i) = \sigma(i,-i)\,S$$





9. Wave propagation near an interface

9. Wave propagation near an interface

9.1 Effect of ground reflections

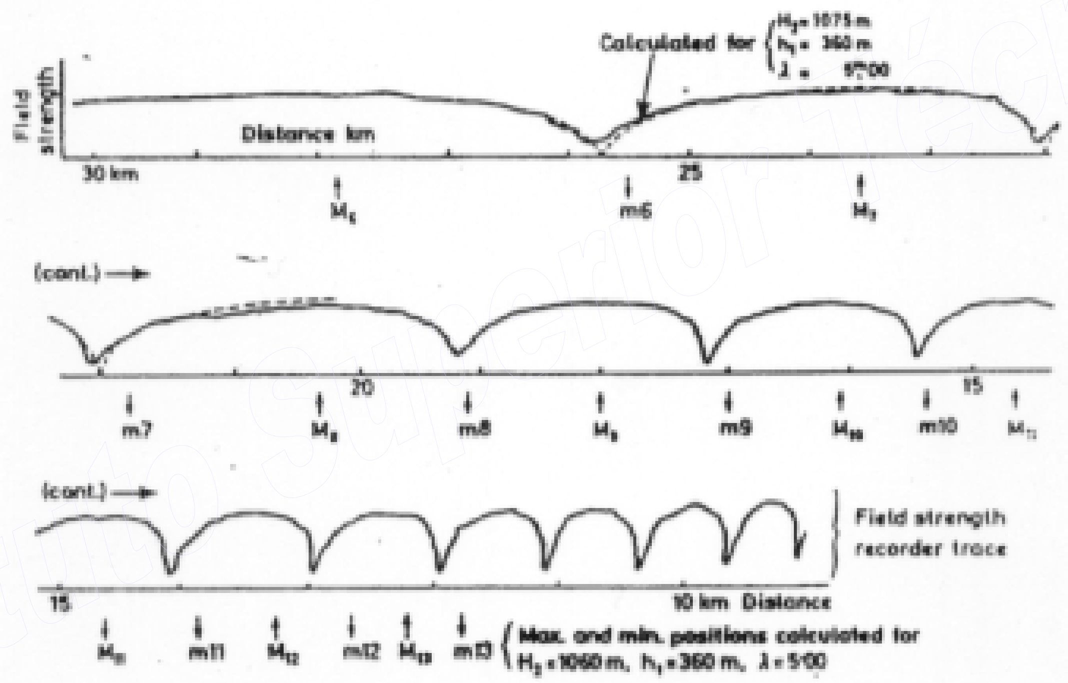
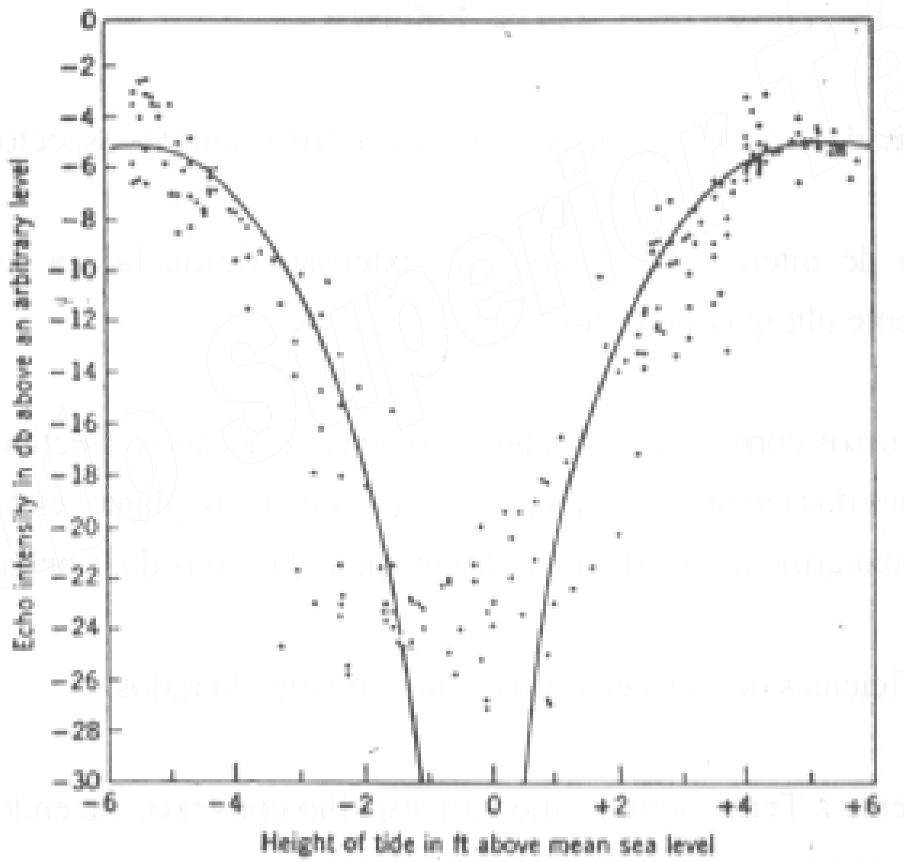


Fig. 3.13 Variação da amplitude do campo, medida num avião voando a altitude constante

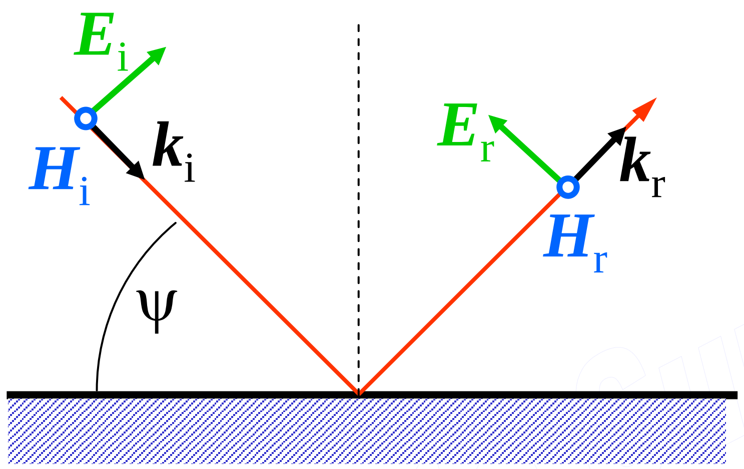
9. Wave propagation near an interface

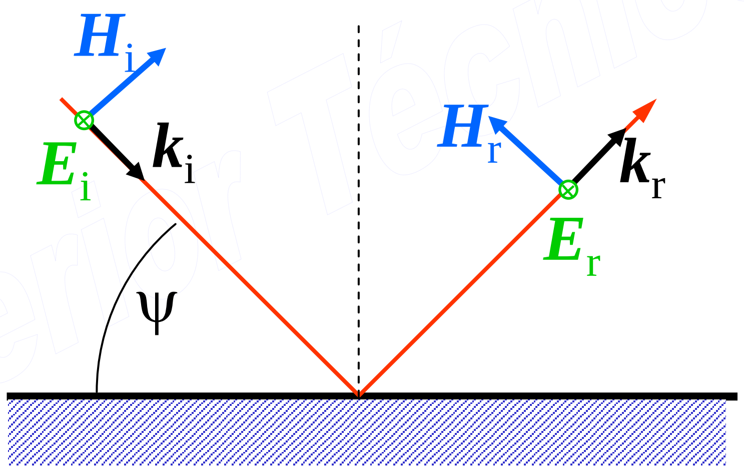
9.2 Effect of reflection on radar performance

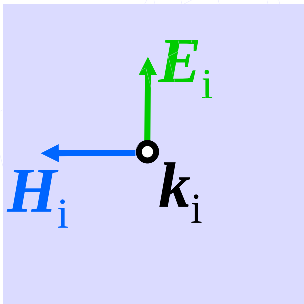


10. Fresnel Coefficients

10.1 Polarisation



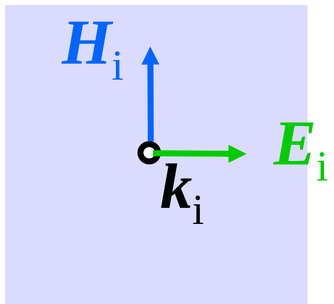




Parallel polarisation

or

Vertical polarisation



Perpendicular polarisation

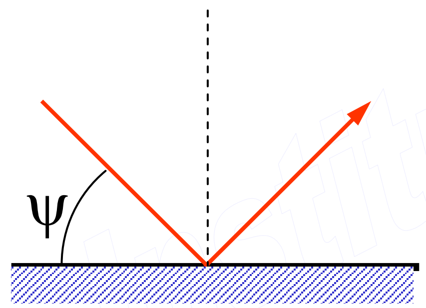
or

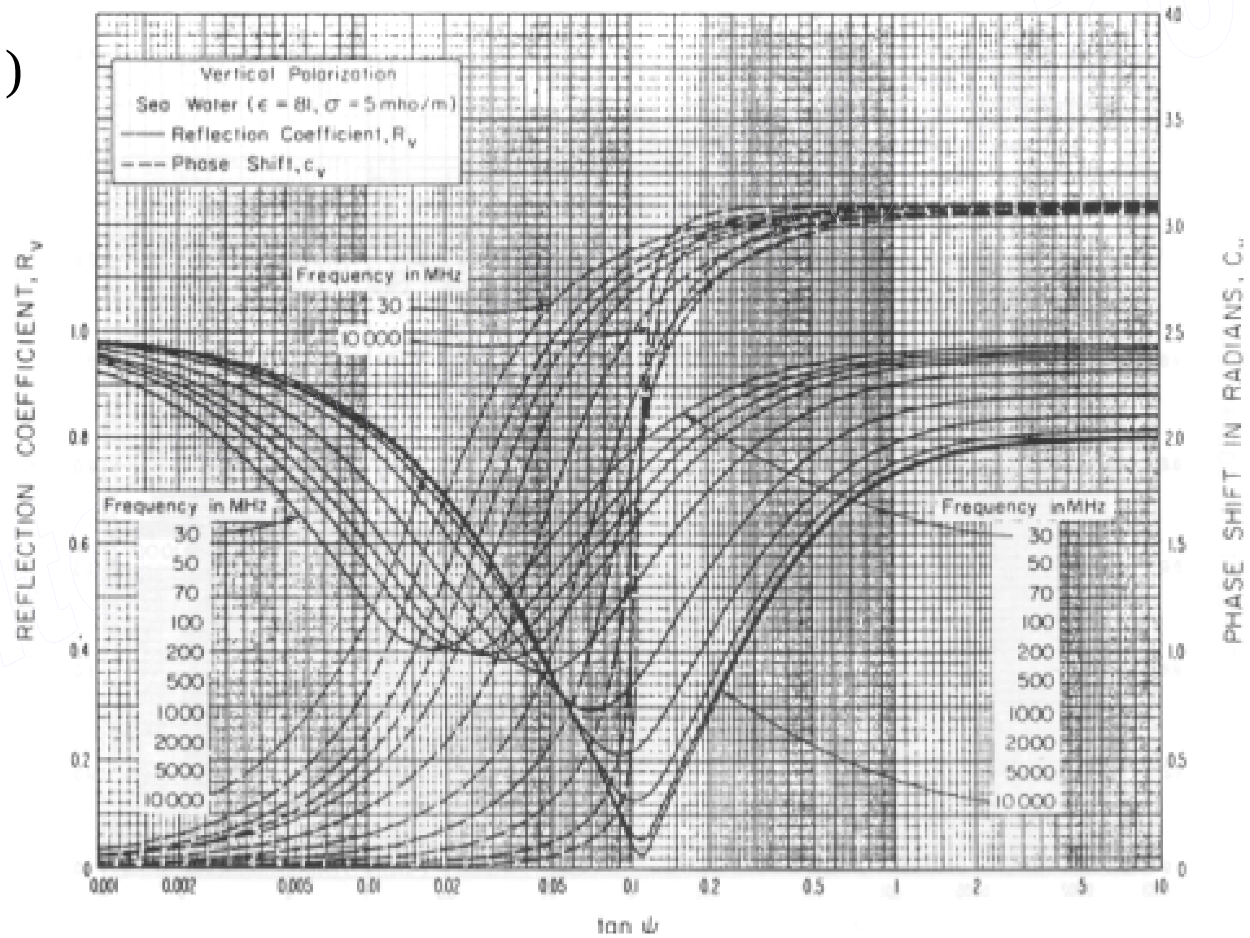
Horizontal polarisation

10. Fresnel Coefficients

10.1 Sea water, Vertical polarization

$$\Gamma_V = R_V \exp - j(\pi - c_V)$$

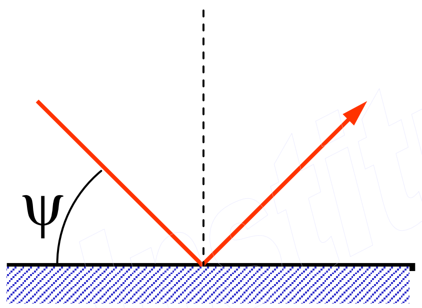


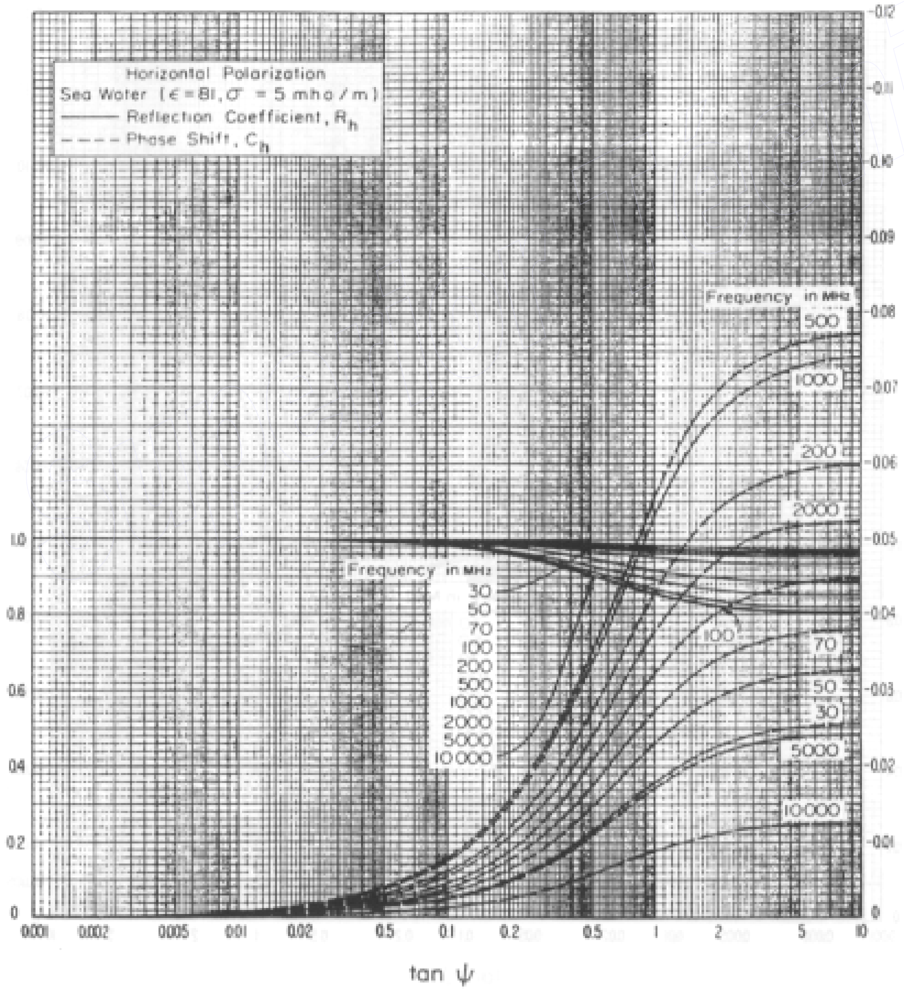


10. Fresnel Coefficients

10.1 Sea water, Horizontal polarization

$$\Gamma_H = R_H \exp - j(\pi - c_H)$$

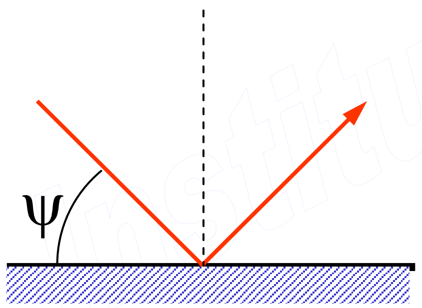


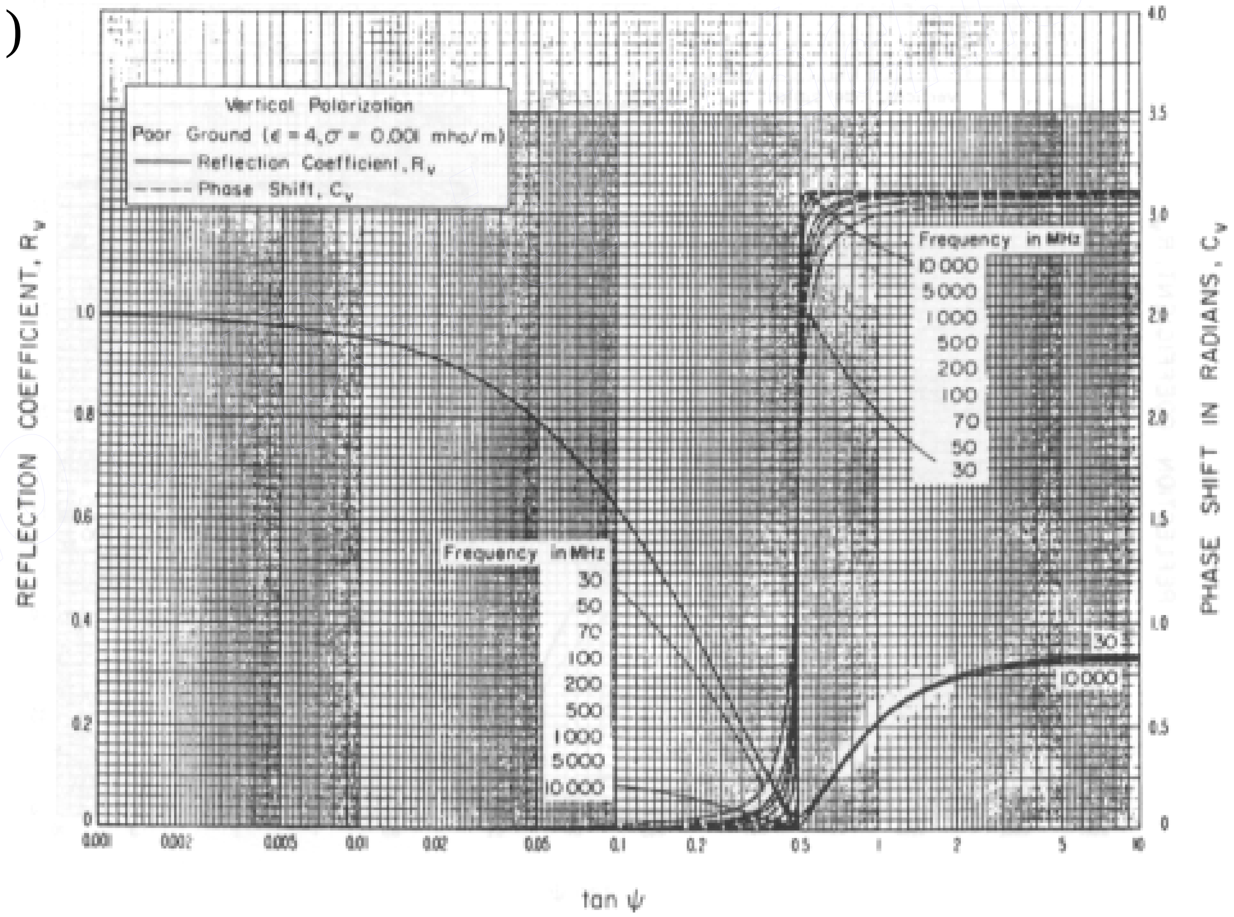


10. Fresnel Coefficients

10.1 Dry soil, Vertical polarization

$$\Gamma_V = R_V \exp - j(\pi - c_V)$$

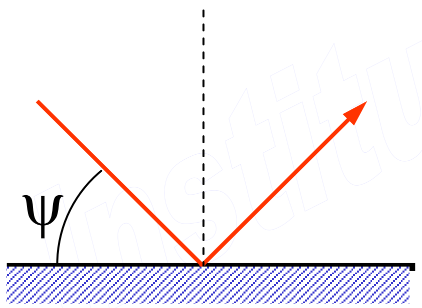


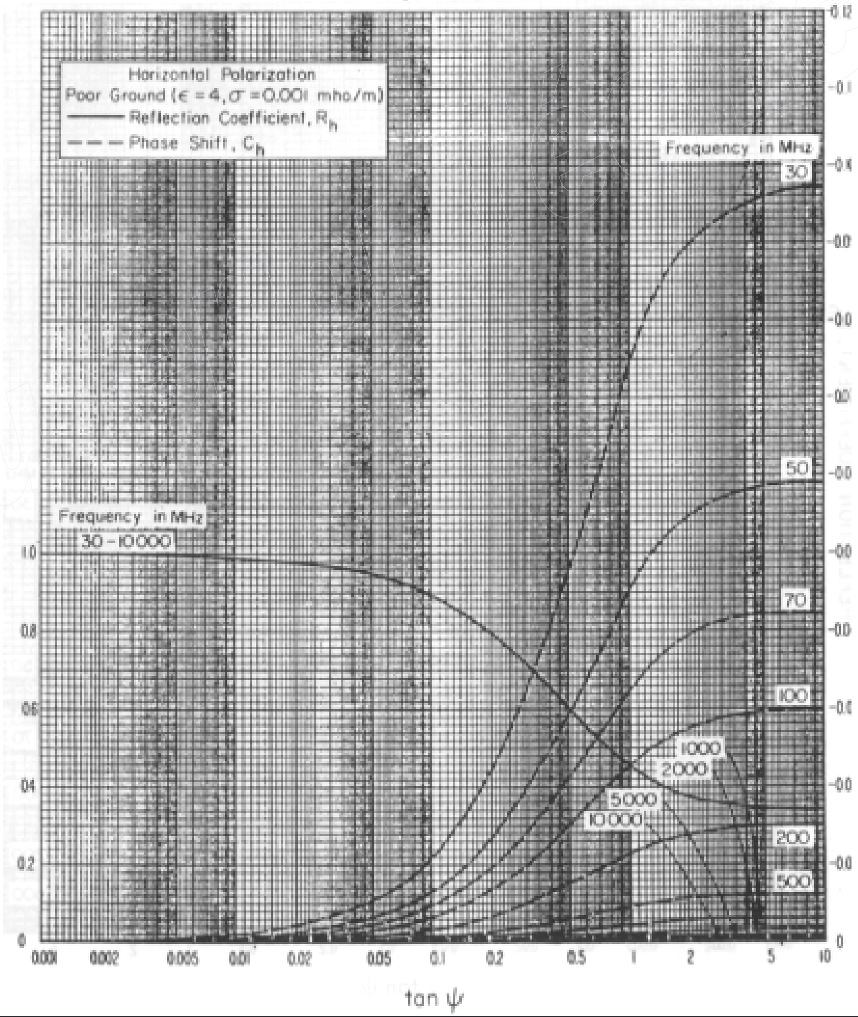


10. Fresnel Coefficients

10.1 Dry soil, Horizontal polarization

$$\Gamma_H = R_H \exp - j(\pi - c_H)$$





10. Fresnel Coefficients

10.5 Sea water, experimental results